

## Fat-Soluble Vitamins

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Vitamins are essential nutrients your body needs in small amounts for various roles in the human body. Vitamins are divided into two groups: water-soluble (B-complex and C) and fat-soluble (A, D, E and K). Unlike water-soluble vitamins that need regular replacement in the body, fat-soluble vitamins are stored in the liver and fatty tissues, and are eliminated much more slowly than water-soluble vitamins.

Because fat-soluble vitamins are stored for long periods, they generally pose a greater risk for toxicity than water-soluble vitamins when consumed in excess. Eating a normal, well-balanced diet will not lead to toxicity in otherwise healthy individuals. However, taking vitamin supplements that contain mega doses of vitamins A, D, E and K may lead to toxicity. Remember, the body only needs small amounts of any vitamin.

While diseases caused by a lack of fat-soluble vitamins are rare in the United States, symptoms of mild deficiency can develop without adequate amounts of vitamins in the diet. Additionally, some health problems may decrease the absorption of fat, and in turn, decrease the absorption of vitamins A, D, E and K. Consult your doctor about this.

Table 1 lists sources of fat-soluble vitamins, their basic functions in the body, major deficiency symptoms caused by a lack of these vitamins, and symptoms of over-consumption.

### Vitamin A

Vitamin A, also called retinol, has many functions in the body. In addition to helping the eyes adjust to light changes, vitamin A plays an important role in bone growth, tooth development, reproduction, cell division and gene expression. Also, the skin, eyes and mucous membranes of the mouth, nose,

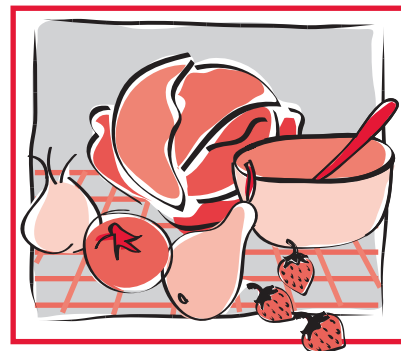
throat and lungs depend on vitamin A to remain moist.

The best way to ensure your body gets enough vitamin A is to eat a variety of foods. Vitamin A is supplied primarily by certain foods of animal origin like dairy products, fish and liver. Some foods of plant origin contain beta-carotene, an antioxidant that the body converts to vitamin A. Beta-carotene, or provitamin A, comes from fruits and vegetables. Carrots, pumpkin, winter squash, dark green leafy vegetables and apricots are rich sources of beta-carotene.

The recommendation for vitamin A intake is expressed as micrograms (mcg) of retinol activity equivalents (RAE). Retinol activity equivalents account for the fact that the body converts only a portion of beta-carotene to retinol. One RAE equals 1 mcg of retinol or 12 mcg of beta-carotene (see Table 2).

True vitamin A deficiency in the United States is rare. Night blindness and very dry, rough skin may indicate a lack of vitamin A. Other signs of possible vitamin A deficiency include decreased resistance to infections, faulty tooth development, and slower bone growth.

In the United States, toxic or excess levels of vitamin A are of more concern than deficiencies. The tolerable upper intake level for adults is 3,000 mcg RAE. It would be difficult to reach this level consuming food alone. But some multivitamin supplements contain high doses of vitamin A. If you take a multivitamin, check the label to be sure the majority of vitamin A provided is in the form of beta-carotene, which appears to be safe. Symptoms of vitamin A toxicity include dry, itchy skin, headache, nausea, and loss of appetite. Signs of severe overuse over a short period of time include dizziness, blurred vision and slowed growth. Vitamin A toxicity also can cause severe birth defects and may increase the risk for hip fractures.



### Quick Facts

- Small amounts of vitamins A, D, E and K are needed to maintain good health.
- Foods that contain these vitamins will not lose them when cooked.
- The body does not need these every day and stores them in the liver when not used.
- Most people do not need vitamin supplements.
- Megadoses of vitamins A, D, E or K can be toxic and lead to health problems.

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**Table 1. Vitamin facts.**

Vitamin	Source	Physiological functions	Deficiency	Overconsumption
A (retinol) (provitamin A, such as beta carotene)	Vitamin A: liver, vitamin A fortified milk and dairy products, butter, whole milk, cheese, egg yolk. Provitamin A: carrots, leafy green vegetables, sweet potatoes, pumpkins, winter squash, apricots, cantaloupe	Helps to form skin and mucous membranes and keep them healthy, thus increasing resistance to infections; essential for night vision; promotes bones and tooth development. Beta carotene is an antioxidant and may protect against cancer.	Mild: night blindness, diarrhea, intestinal infections, impaired vision. Severe: inflammation of eyes, keratinization of skin and eyes. Blindness in children.	Mild: nausea, irritability, blurred vision. Severe: growth retardation, enlargement of liver and spleen, loss of hair, bone pain, increased pressure in skull, skin changes.
D	Vitamin D-fortified dairy products, fortified margarine, fish oils, egg yolk. Synthesized by sunlight action on skin.	Promotes hardening of bones and teeth, increases the absorption of calcium.	Severe: rickets in children; osteomalacia in adults.	Mild: nausea, weight loss, irritability. Severe: mental and physical growth retardation, kidney damage, movement of calcium from bones into soft tissues.
E	Vegetable oil, margarine, butter, shortening, green and leafy vegetables, wheat germ, whole grain products, nuts, egg yolk, liver.	Protects vitamins A and C and fatty acids; prevents damage to cell membranes. Antioxidant.	Almost impossible to produce without starvation; possible anemia in low birth-weight infants.	Nontoxic under normal conditions. Severe: nausea, digestive tract disorders.
K	Dark green leafy vegetables, liver; also made by bacteria in the intestine.	Helps blood to clot.	Excessive bleeding.	None reported.

Physicians sometimes recommend that young infants take vitamin supplements that contain vitamin A. However, toddlers and children need protection from too much vitamin A due to their smaller body size. Typical foods eaten in large amounts by toddlers and children usually contain sufficient amounts of vitamin A. Provide a variety of foods for your children, and if in doubt, check with a pediatrician or Registered Dietitian.

## Vitamin D

Vitamin D plays a critical role in the body's use of calcium and phosphorus. It increases the amount of calcium absorbed from the small intestine and helps form and maintain bones. Children especially need adequate amounts of vitamin D to develop strong bones and healthy teeth.

The primary food sources of vitamin D are milk and other dairy products fortified with vitamin D. Vitamin D is also found in oily fish (e.g., herring, salmon and sardines) as well as in cod liver oil. In addition to the vitamin D provided by food, we obtain vitamin D through our skin which makes vitamin D in response to sunlight.

An Adequate Intake (AI) has been established for vitamin D (see Table 2). The AIs for vitamin D appear as micrograms (mcg) of cholecalciferol. Ten mcg of cholecalciferol equals 400 International Units (IU).

Symptoms of vitamin D deficiency in growing children include rickets (long, soft bowed legs) and flattening of the back of the skull. Vitamin D deficiency in adults is called osteomalacia, which results in muscular weakness and weak bones. These conditions are rare in the United States.

The tolerable upper intake level for vitamin D is set at 50 mcg for people 1 year of age and older (see Table 3). High doses of vitamin D supplements coupled with large amounts of fortified foods may cause accumulations in the liver and produce signs of poisoning. Signs of vitamin D toxicity include excess calcium in the blood, slowed mental and physical growth, decreased appetite, nausea and vomiting.

It is important that infants and young children do not consume excess amounts of vitamin D regularly. Children exposed to the sun for 5 to 10 minutes daily will produce enough vitamin D. However, if children live in inner cities, wear clothes that cover most of their skin or live in northern climates where little sun is seen in the winter, then vitamin D deficiency may occur. Rather than give children a supplement, add fortified foods to their diet, such as vitamin D fortified milk and other dairy products.

Vitamin D deficiency has been associated with increased risk of common cancers, autoimmune diseases, hypertension and infectious disease. In the absence of adequate sun exposure,

at least 800 to 1,000 IU of Vitamin D3 may be needed to reach the circulating level required to maximize Vitamin D's beneficial health effects.

## Vitamin E

Vitamin E acts as an antioxidant, protecting vitamins A and C, red blood cells and essential fatty acids from destruction. Research from a decade ago suggested that taking antioxidant supplements, vitamin E in particular, might help prevent heart disease and cancer. However, newer findings indicate that people who take antioxidant supplements are not better protected against heart disease and cancer than non-supplement users. On the other hand, there are many studies that show a link between regularly eating antioxidant-rich fruits and vegetables and a lower risk for heart disease, cancer and several other diseases.

The RDA for vitamin E is based on the most active and usable form called

Vitamin requirements are expressed in small units. Most are given in milligrams (mg) or micrograms (mcg). When comparing vitamin amounts on labels, note whether values are in micrograms (mcg), milligrams (mg) or International Units (IU). Make sure you compare the same units.

**Table 2. Dietary Reference Intakes (DRI) for fat soluble vitamins.**

Life Stage Group	Vitamin A (mcg <sup>1</sup> )	Vitamin A (IU)	Vitamin D (mcg <sup>2</sup> )	Vitamin D (IU)	Vitamin E (mg $\alpha$ -TE <sup>3</sup> )	Vitamin E (IU)
<b>Infants</b>						
0.0-0.5 mo	400*	1333	5*	200	4*	6
0.5-1.0 mo	500*	1666	5*	200	5*	7.5
<b>Children</b>						
1-3	300	1000	5*	200	6	9
4-8	400	1333	5*	200	7	10.5
<b>Males</b>						
9-13	600	2000	5*	200	11	16.5
14-18	900	3000	5*	200	15	22.5
19-30	900	3000	5*	200	15	22.5
31-50	900	3000	5*	200	15	22.5
51-70	900	3000	10*	400	15	22.5
71+	900	3000	15*	600	15	22.5
<b>Females</b>						
9-13	600	2000	5*	200	11	16.5
14-18	700	2333	5*	200	15	22.5
19-30	700	2333	5*	200	15	22.5
31-50	700	2333	5*	200	15	22.5
51-70	700	2333	10*	200	15	22.5
71+	700	2333	15*	200	15	22.5
<b>Pregnant</b>						
≤18	750	2500	5*	200	15	22.5
19-30	770	2566	5*	200	15	22.5
31-50	770		5*	200	15	22.5
<b>Lactating</b>						
≤18	1,200	4000	5*	200	19	28.8
19-30	1,300	4333	5*	200	19	28.8
31-50	1,300	4333	5*	200	19	28.8

\* Indicates an Adequate Intake (AI). All other values are Recommended Dietary Allowance (RDA).

<sup>1</sup> As retinol activity equivalents (RAEs). 1 RAE = 1mcg retinol or 12 mcg beta-carotene.

<sup>2</sup> As cholecalciferol. 10 mcg cholecalciferol = 400 IU of vitamin D.

<sup>3</sup> As alpha-tocopherol equivalents. 1 mg of alpha-tocopherol = 1.5 IU of vitamin E.

alpha-tocopherol (see Table 2). One milligram of alpha-tocopherol equals to 1.5 International Units (IU).

About 60 percent of vitamin E in the diet comes from vegetable oil or products made with vegetable oils. Therefore, good food sources of vitamin E include vegetable oils and margarines. Vitamin E is also found in fruits and vegetables, grains, nuts, seeds and fortified cereals. Deficiencies of vitamin E only occur in premature infants and people unable to absorb fats.

The tolerable intake levels for vitamin E are shown in Table 3. Large doses of vitamin E pose a hazard to people who take blood-thinning medications. People taking statin drugs are not advised to take supplemental vitamin E because it may interfere with how the medication works.

One milligram is 0.001 gram, about 1/28 of an ounce. One microgram is 0.000001 of a gram.

## Vitamin K

Naturally produced by the bacteria in the intestines, vitamin K plays an essential role in normal blood clotting and helps promote bone health. Good food sources of vitamin K are green vegetables such as turnip greens, spinach, cauliflower, cabbage and broccoli, and certain vegetables oils including soybean oil, cottonseed oil, canola oil and olive oil. Animal foods, in general, contain limited amounts of vitamin K.

To help ensure people receive sufficient amounts of vitamin K, an Adequate Intake (AI) has been established for each age group (see Table 2). Without sufficient amounts of vitamin K, hemorrhaging can occur. Deficiencies may appear in infants, or in people who take anticoagulants or antibiotic drugs. Newborn babies lack the intestinal bacteria to produce vitamin K and need a supplement for the first week. People on anticoagulant drugs (blood thinners) may become deficient in vitamin K, but should not change their vitamin

K intake without consulting a physician because the effectiveness of the drug may be affected. People taking antibiotics may lack vitamin K temporarily because intestinal bacteria are sometimes killed as a result of long-term use of antibiotics. Also, people with chronic diarrhea may have problems absorbing sufficient amounts of vitamin K through the intestine and should consult their physician to determine if supplementation is necessary.

Although a tolerable upper intake level has not been established for vitamin K, excessive amounts can cause the breakdown of red blood cells and liver damage. Large doses are not advised.

## Standards for Measuring Intake

Dietary Reference Intakes (DRI) are dietary standards for desirable and/or safe vitamin intake levels published by the Food and Nutrition Board of the National Academy of Sciences National Research Council. DRIs include three values: recommended dietary allowances (referred to as RDAs), which are intended to meet the nutrient needs of healthy individuals; tolerable upper intake levels (UL), designed to help people avoid harmful effects caused by consuming too much of a nutrient; and adequate intakes (AI), which are established when there is not enough scientific evidence to set an RDA and are based on diets known to be nutritionally adequate for U.S. and Canadian populations.

## References

- Complete Book of vitamins and Minerals (2000). Publications International, Ltd.
- Facts About Dietary Supplements (2001). NIH Clinical Center. Available on <http://www.cc.nih.gov/cc/supplements/intro.html>
- Hollick, M.F., Chen TC.. Vit. D deficiency: a worldwide problem with health consequences. American Journal of Clinical Nutrition. 2008. April 87 (4): 1080S-6S.
- Insel, P. et al (2001). Nutrition. Sudbury, MA: Jones and Bartlett publishers.

**Table 3. Tolerable upper intake levels (UL)\*.**

<b>Life stage group</b>	<b>Vitamin A (mcg)</b>	<b>Vitamin D (mcg)</b>	<b>Vitamin E (mg <math>\alpha</math>-TE)</b>
<b>Infants</b>			
0.0-0.5 mo	600	25	ND <sup>1</sup>
0.5-1.0 mo	600	25	ND
<b>Children</b>			
1-3 y	600	50	200
4-8 y	900	50	300
<b>Males, Females</b>			
9-13 y	1,700	50	600
14-18 y	2,800	50	800
19-70 y	3,000	50	1,000
>71 y	3,000	50	1,000
<b>Pregnant &amp; Lactating</b>			
$\leq$ 18 y	2,800	50	800
19-50 y	3,000	50	1,000

\* A UL for vitamin K was not established.

<sup>1</sup> ND = not determinable due to insufficient data.

Dietary Reference intakes for Calcium, Phosphorus, Magnesium, Vitamin D and Fluoride. Washington, DC: National Academy Press, 1997.

Dietary Reference Intakes for Vitamin C, Vitamin E, Selenium, and Carotenoids. Washington, DC: National Academy Press, 2000.

Dietary Reference Intakes for Vitamin A, Vitamin K, Arsenic, Boron, Chromium, Copper, Iodine, Iron, Manganese, Molybdenum, Nickel, Silicon, Vanadium, and Zinc. Washington, DC: National Academy Press, 2001.

Table 2 lists the recommended amounts of fat-soluble vitamins that individuals in the United States need daily for good health. Table 3 provides the tolerable upper intake levels.